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L2: Entry 1 of 1 File: USPT Jun 29, 1999

DOCUMENT-IDENTIFIER: US 5917646 A
TITLE: Rotatable lens transmissive twisting ball display

US PATENT NO. (1):
5917646

Brief Summary Text (11):
The gyricon display, also called the twisting-ball display, rotary ball display, particle display, dipolar particle light valve, etc., offers a technology for making a form of electric paper. Briefly, a gyricon display is an addressable display made up of a multiplicity of optically anisotropic balls, each of which can be selectively rotated to present a desired face to an observer. For example, a gyricon display can incorporate balls each having two distinct hemispheres, one black and the other white, with each hemisphere having a distinct electrical characteristic (e.g., zeta potential with respect to a dielectric fluid) so that the balls are electrically as well as optically anisotropic. The black-and-white balls are embedded in a sheet of optically transparent material, such as an elastomer layer, that contains a multiplicity of spheroidal cavities and is permeated by a transparent dielectric fluid, such as a plasticizer. The fluid-filled cavities accommodate the balls, one ball per cavity, so as to prevent the balls from migrating within the sheet. A ball can be selectively rotated within its respective fluid-filled cavity, for example by application of an electric field, so as to present either the black or the white hemisphere to an observer viewing the surface of the sheet. Thus, by application of an electric field addressable in two dimensions (as by a matrix addressing scheme), the black and white sides of the balls can be caused to appear as the image elements (e.g., pixels or subpixels) of a displayed image.

Detailed Description Text (124):
The incident light that encounters a gyricon display need not be restricted to visible light. Given suitable materials for the gyricon balls, the incident "light" can be, for example, infrared light or ultraviolet light, and such light can be modulated by the gyricon.

CLAIMS:

9. The combination of claim 1 wherein the optically transmissive region of the particle comprises a spheroidal ball.

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L3: Entry 1 of 1 File: USPT Jun 29, 1999

DOCUMENT-IDENTIFIER: US 5917646 A
TITLE: Rotatable lens transmissive twisting ball display

US PATENT NO. (1):
5917646

Brief Summary Text (11):
The gyricon display, also called the twisting-ball display, rotary ball display, particle display, dipolar particle light valve, etc., offers a technology for making a form of electric paper. Briefly, a gyricon display is an addressable display made up of a multiplicity of optically anisotropic balls, each of which can be selectively rotated to present a desired face to an observer. For example, a gyricon display can incorporate balls each having two distinct hemispheres, one black and the other white, with each hemisphere having a distinct electrical characteristic (e.g., zeta potential with respect to a dielectric fluid) so that the balls are electrically as well as optically anisotropic. The black-and-white balls are embedded in a sheet of optically transparent material, such as an elastomer layer, that contains a multiplicity of spheroidal cavities and is permeated by a transparent dielectric fluid, such as a plasticizer. The fluid-filled cavities accommodate the balls, one ball per cavity, so as to prevent the balls from migrating within the sheet. A ball can be selectively rotated within its respective fluid-filled cavity, for example by application of an electric field, so as to present either the black or the white hemisphere to an observer viewing the surface of the sheet. Thus, by application of an electric field addressable in two dimensions (as by a matrix addressing scheme), the black and white sides of the balls can be caused to appear as the image elements (e.g., pixels or subpixels) of a displayed image.

Drawing Description Text (12):
FIG. 10 illustrates a vapor-deposition (thin film) overcoat on a spherical lens ball;

Detailed Description Text (58):
A vapor-deposition film can be applied to balls 91 as a final step after the photoresist exposure and development described above is complete, to produce an opaque aperture mask or reflective aperture stop. While balls 91 remain in holes 93, a vapor is deposited on the balls 91 through holes 93 from a source external to chamber 90, in a manner similar to that previously used to apply the photoresist from source 98. A thin film of the vaporized material thus coats the partial hemispheres of balls 91 that are exposed through holes 93, but does not enter the interior of chamber 90 and so does not coat the portions of balls 91 that face towards the inside of chamber 90. The deposited thin film covers all of the hemispheres exposed through holes 93, including portions of balls 91 that were previously coated by photoresist. This is illustrated in the enlargement of FIG. 10 for an exemplary ball 91b, which has a photoresist coating 100 in the form of an aperture mask and a thin film 102 overcoating that. A portion of plate 92 through which ball 91b is exposed via hole 93b to vapor from a source 98' can also be seen. Source 98' and chamber 90 can be placed in a larger vacuum chamber (not shown) to facilitate the film deposition.

Detailed Description Text (59):
The material used to form film 102 can be, for example, an opaque nonconductive material formed by codepositing indium and magnesium fluoride. For an aperture stop, it can also be a metallic film, such as chrome. Use of a metallic film is not

compounds, such as anils, disulfoxides, hydrazones, oxazones, semicarbazones, stilbene derivatives, o-nitrobenzyl derivatives, spiro compounds, and the like, and in inorganic compounds, such as metal oxides, alkaline earth metal sulfides, titanates, mercury compounds, copper compounds, minerals, transition metal compounds such as carbonyls, and the like. Photochromic materials are known in applications such as photochromic glasses, which are useful as, for example, ophthalmic lenses.

Brief Summary Text (62):
U.S. Pat. No. 5,917,646 (Sheridon), the disclosure of which is totally incorporated herein by reference, discloses a combination of an optically transmissive dielectric fluid having a first refractive index and an optically anisotropic particle rotatably disposed in the fluid. The particle has at least one optically transmissive region having a second refractive index. The particle provides a first optical modulation characteristic when disposed in the fluid in a first orientation with respect to a flux of optical energy, and further provides a second optical modulation characteristic when disposed in the fluid in a second orientation with respect to a flux of optical energy. The particle has an anisotropy for providing an electrical dipole moment, the electrical dipole moment rendering the particle electrically responsive such that when the particle is rotatably disposed in an electric field while the electrical dipole moment of the particle is provided, the particle tends to rotate to an orientation in which the electrical dipole moment aligns with the field. For example, the disposition of the particle in the fluid can give rise to the electrical dipole moment of the particle. The fluid-particle combination can be used to make a gyricon or rotating-particle display in which each rotatable particle (e.g., spherical ball) in the display acts as a lens.

Brief Summary Text (63):
U.S. Pat. No. 5,777,782 (Sheridon), the disclosure of which is totally incorporated herein by reference, discloses a gyricon or rotating-particle display having an auxiliary optical structure. The display includes a substrate with an optically transmissive window, a plurality of particles disposed in the substrate, and an optical focusing element optically coupled to the window. Each particle has an anisotropy for providing an electrical dipole moment, the electrical dipole moment rendering the particle electrically responsive such that when the particle is rotatably disposed in an electric field while the electrical dipole moment of the particle is provided, the particle tends to rotate to an orientation in which the electrical dipole moment aligns with the field. A rotatable disposition of each particle is achievable while the particle is thus disposed in the substrate; when the particle is in this rotatable disposition, it is not attached to the substrate. Each particle, when rotatably disposed in the substrate, is disposable in first and second rotational orientations with respect to the optically transmissive window. Each particle provides a first optical modulation characteristic when disposed in its first orientation with respect to a flux of optical energy through the window, and further provides a second optical modulation characteristic when disposed in its second orientation with respect to a flux of optical energy through the window. The optical focusing element can be optically refractive; for example, it can include an array of converging lenses, such as a "fly's-eye" array of microlenses. In this case, the particles can be disposed in an array that is registered with the lens array.

Brief Summary Text (64):
U.S. Pat. No. 5,815,306 (Sheridon et al.), the disclosure of which is totally incorporated herein by reference, discloses a gyricon or rotating-particle display having an "eggcrate" substrate. The display includes a substrate having a cavity-containing matrix whose cavities are disposed substantially in a single layer and are arranged within the matrix substantially in a geometrically regular pattern, and a plurality of optically anisotropic particles disposed in the cavities in the substrate, with each cavity containing at most one of the optically anistropic particles. A rotatable disposition of each particle is achievable while the particle is thus disposed in the substrate; the particle, when in its rotatable disposition, is not attached to the substrate. Each particle, for example, can have an anisotropy for providing an electrical dipole moment, the electrical dipole moment rendering the particle electrically responsive such that when the particle is rotatably disposed in an electric field while the electrical dipole moment of the particle is provided, the particle tends to rotate to an orientation in which the electrical dipole moment aligns with the field. The single layer of cavities can be substantially planar, and

the geometrical pattern of cavities can be a two-dimensional array pattern in the plane of the layer, such as a hexagonal, rectangular, or rhomboidal array pattern. The substrate can further include first and second members between which members the matrix is disposed; at least one of the members can include an optically transmissive window through which a flux of optical energy can pass so as to be incident on the particles.

Brief Summary Text (77):
U.S. Pat. No. 5,754,332 (Crowley), the disclosure of which is totally incorporated herein by reference, discloses a gyricon or twisting-ball display having superior reflectance characteristics comparing favorably with those of white paper. The display is based on a material made up of optically anisotropic particles, such as bichromal balls, disposed substantially in a monolayer in a substrate. The particles are closely packed with respect to one another in the monolayer, preferably so that adjacent particle surfaces are as close to one another as possible. A rotatable disposition of each particle is achievable while the particle is thus disposed in the substrate; for example, the particles can already be rotatable in the substrate, or can be rendered rotatable in the substrate by a nondestructive operation performed on the substrate. In particular, the particles can be situated in an elastomer substrate that is expanded by application of a fluid thereto so as to render the particles rotatable therein. A particle, when in its rotatable disposition, is not attached to the substrate. A reflective-mode display apparatus can be constructed from a piece of the material together a mechanism (e.g., addressing electrodes) for facilitating rotation of at least one of the particles. The light reflected from the display is reflected substantially entirely from the monolayer of balls, so that lower layers are not needed. By eliminating the lower layers, the display can be made thinner, which in turn provides further advantages, such as lower drive voltage and better resolution due to better control of fringing fields.

Brief Summary Text (78):
U.S. Pat. No. 5,808,783 (Crowley), the disclosure of which is totally incorporated herein by reference, discloses a gyricon or twisting-ball display having superior reflectance characteristics comparing favorably with those of white paper. The display is based on a material made up of optically anisotropic particles, such as bichromal balls, disposed in a substrate having a surface. The particles situated closest to the substrate surface form substantially a single layer. Each particle in the layer has a center point, no particle in the layer being disposed entirely behind the center point of any nearest neighboring particle in the layer with respect to the substrate surface. Each particle in the layer has a projected area with respect to the substrate surface. Particles of the set are sufficiently closely packed with respect to one another in the layer that the union of their projected areas exceeds two-thirds of the area of the substrate surface. A rotatable disposition of each particle is achievable while the particle is thus disposed in the substrate; for example, the particles can already be rotatable in the substrate, or can be rendered rotatable in the substrate by a nondestructive operation. In particular, the particles can be situated in an elastomer substrate that is expanded by application of a fluid thereto so as to render the particles rotatable therein. A particle, when in its rotatable disposition, is not attached to the substrate. A reflective-mode display apparatus can be constructed from a piece of the material together with a mechanism (e.g., addressing electrodes) for facilitating rotation of at least one of the particles.

Brief Summary Text (79):
U.S. Pat. No. 5,914,805 (Crowley), the disclosure of which is totally incorporated herein by reference, discloses a gyricon or twisting-ball display having superior reflectance characteristics comparing favorably with those of white paper is based on a material made up of two populations (e.g., two different sizes) of optically anisotropic particles, such as bichromal balls, disposed in a substrate. Particles of the first population, as considered by themselves without the particles of the second population, are disposed in the substrate in a closely packed (e.g., geometrically regular) arrangement having interstices. Particles of the second population are disposed in the interstices of the arrangement. A rotatable disposition of each particle is achievable while the particle is thus disposed in the substrate; for example, the particles can already be rotatable in the substrate, or can be rendered rotatable in the substrate by a nondestructive operation performed on the substrate. In particular, the particles can be situated in an elastomer substrate that is

expanded by application of a fluid thereto so as to render the particles rotatable therein. A particle, when in its rotatable disposition, is not attached to the substrate. A reflective-mode display apparatus can be constructed from a piece of the material together with a mechanism (e.g., addressing electrodes) for facilitating rotation of at least one of the particles.

Brief Summary Text (80):
U.S. Pat. No. 5,825,529 (Crowley), the disclosure of which is totally incorporated herein by reference, discloses a gyricon or twisting-ball display in which optically anisotropic particles, such as bichromal balls, are disposed directly in a working fluid, such as a dielectric liquid, without an elastomer substrate or other cavity-containing matrix. The display apparatus has an optically transmissive viewing surface, behind which the working fluid is disposed with the particles in it. The particles are arranged in a closely packed stable arrangement in which neighboring particles tend to keep one another in place. For example, the particles can be arranged in a hexagonally packed monolayer. The working fluid does not substantially constrain the particles to remain in the stable arrangement, notwithstanding the direct contact of the fluid with the particles.

Brief Summary Text (81):
U.S. Pat. No. 6,147,791 (Sheridon), the disclosure of which is totally incorporated herein by reference, discloses a sheet material for use in a gyricon display in which a rotatable element, which has a portion which is capable of being permanently magnetized may be oriented to experience an attractive force between itself and a soft magnetic material pad. The attractive force between the element and the pad serve to latch the element in place and prevent unwanted display changes from taking place. The element may be constructed to be either cylindrically or spherically shaped. The element and the soft magnetic material pads may be arranged to provide multiple latching states as desired.

Brief Summary Text (85):
U.S. Pat. No. 6,038,059 (Silverman), the disclosure of which is totally incorporated herein by reference, discloses several variations in full-color additive gyricons are shown. Each gyricon shown has been designed for ease of construction by eliminating the need for precise placement of rotating elements, alignment between the gyricon layers, if any, and alignment between the gyricon sheet and the addressing device.

Brief Summary Text (86):
U.S. Pat. No. 6,122,094 (Silverman), the disclosure of which is totally incorporated herein by reference, discloses several variations in full-color additive gyricons. Each gyricon shown has been designed for ease of construction by eliminating the need for precise placement of rotating elements, alignment between the gyricon layers, if any, and alignment between the gyricon sheet and the addressing device.

Brief Summary Text (87):
U.S. Pat. No. 6,162,321 (Silverman), the disclosure of which is totally incorporated herein by reference, discloses several variations in full-color additive gyricons. Each gyricon shown has been designed for ease of construction by eliminating the need for precise placement of rotating elements, alignment between the gyricon layers, if any, and alignment between the gyricon sheet and the addressing device.

Brief Summary Text (88):
U.S. Pat. No. 6,128,124 (Silverman), the disclosure of which is totally incorporated herein by reference, discloses several variations in full-color additive gyricons. Each gyricon shown has been designed for ease of construction by eliminating the need for precise placement of rotating elements, alignment between the gyricon layers, if any, and alignment between the gyricon sheet and the addressing device.

Brief Summary Text (90):
U.S. Pat. No. 6,055,091 (Sheridon et al.), the disclosure of which is totally incorporated herein by reference, discloses a gyricon or twisting-particle display based on nonspheroidal (e.g., substantially cylindrical) optically anisotropic particles disposed in a substrate. The particles can be bichromal cylinders, preferably aligned parallel to one another and packed close together in a monolayer. A rotatable disposition of each particle is achievable while the particle is thus

disposed in the substrate; for example, the particles can already be rotatable in the substrate, or can be rendered rotatable in the substrate by a nondestructive operation performed on the substrate. In particular, the substrate can be made up of an elastomer that is expanded by application of a fluid thereto so as to render the particles rotatable therein. A particle, when in its rotatable disposition, is not attached to the substrate. The close-packed monolayer configuration of particles provides excellent brightness characteristics and relative ease of manufacture as compared with certain other high-brightness gyricon displays. The substrate containing the cylinders can be fabricated with the swelled-elastomer techniques known from spherical-particle gyricon displays, with a simple agitation process step being used to align the cylinders within the sheeting material. Techniques for fabricating the cylinders are also disclosed.

Brief Summary Text (94):
Sheridon, "The Gyricon--A Twist Ball Display," Proceedings of the Society of Information Display, Vol. 18/3 and 4 (1977), the disclosure of which is totally incorporated herein by reference, discloses a gyricon ambient light viewed display consisting of an elastomer sheet contained between transparent electrodes. The elastomer sheet changes from black to white or from white to black depending upon the polarity of the electrical field that is impressed between the electrodes. The elastomer sheet contains a high loading of small balls that are black on one hemisphere and white on the other. Each ball is contained in an individual oil-filled spherical cavity and is free to rotate in response to the applied electric field.

material.

Brief Summary Text (16):
Copending application U.S. Ser. No. 09/438,894, filed Nov. 12, 1999, entitled "Field Addressed Displays Using Charge Discharging in Conjunction With Charge Retaining Island Structures," with the named inventors Matthew E. Howard and Edward A. Richley, the disclosure of which is totally incorporated herein by reference, discloses an electric reusable paper sheet that uses a pattern of conductive charge-retaining islands on the outward-facing side of the first of two thin layers used to encapsulate an electric reusable paper substrate which interact with conductive areas in the encapsulating sheet. The second encapsulating layer may also be coated with a conductive material, or made of a conductive material, and may or may not be patterned. The electric reusable paper substrate and two encapsulating layers comprise a sheet of gyricon electric reusable paper on which images can be written and erased repeatedly. The patterned charge-retaining islands of the first encapsulating layer receive electric charges from an external charge-transfer device. After the charge-transfer device is removed, the conductive, charge-retaining islands hold electric charge, creating an electric field in the electric reusable paper sufficient to cause an image change.

Brief Summary Text (22):
Copending application U.S. Ser. No. 09/465,801, filed Dec. 17, 1999, entitled "System and Method for Rotatable Element Assembly and Laminate Substrate Assembly," with the named inventors David K. Biegelsen, Joseph Crowley, and Alexander E. Silverman, the disclosure of which is totally incorporated herein by reference, discloses methods and systems used to assemble composite rotatable-element components and used to form a laminate substrate system, and use a plurality of rotatable-element components or rotatable-element component material of two classes. Each class is defined by a common response or responses to incident electromagnetic radiation of interest. The method for assembling a composite rotatable-element component comprises: dispersing a plurality of rotatable-element components of a first class to first preferred positions on a first carrier; dispersing a plurality of rotatable-element components of a second class to second preferred positions on a second carrier; performing a first manipulation of the first carrier and the second carrier such that one of the plurality of rotatable-element components of a first class and one of the plurality of rotatable-element components of a second class touch at a first contact point; and performing a second manipulation of the rotatable-element components that touch such that they bond to form a composite rotatable-element component. The method for assembling a laminate substrate further comprises: performing a third manipulation of the first carrier and the second carrier such that they touch at a set of second contact points; and performing a fourth manipulation of the first carrier and the second carrier such that they bond to form the laminate substrate.

Brief Summary Text (26):
Copending application U.S. Ser. No. 09/517,522, filed Mar. 2, 2000, entitled "Rotating Element Sheet Material With Reversible Highlighting," with the named inventor Alexander E. Silverman, the disclosure of which is totally incorporated herein by reference, discloses a kit comprising rotating element sheet material, a highlighting implement, and an erasing implement, a binder, and a method of use. The rotating element sheet material comprises a plurality of first rotatable elements and a plurality of second rotatable elements disposed in a substrate. Each first rotatable element in the plurality has a first collection of responses to incident electromagnetic radiation of interest. One response in the first collection renders the first rotatable element transparent-clear to incident electromagnetic energy of interest, and a second response renders the first rotatable element opaque to incident electromagnetic energy of interest, The first rotatable element also exhibits a first work function. Likewise, each second rotatable element has a second collection of responses to incident electromagnetic radiation of interest. A first response in the second collection renders the second rotatable element transparent-clear to the incident electromagnetic energy of interest. A second response renders the second rotatable element transparent-colored to the incident electromagnetic energy of interest. The second rotatable elements also exhibit a second work function that is less than the first work function. The addressing implement introduces a vector field in a first direction in the substrate where the vector field has a magnitude greater than the second work function and less than the first work function. In addition, the

recommended for aperture masks, because the large conductive area provided by such a film can interfere with the formation of the ball's dipole moment, and thus with ball rotation.

Detailed Description Text (60):
Once film 102 is deposited over the photoresist, balls 91 are removed from chamber 90 and are immersed in a photoresist stripping solution. The stripping solution penetrates through tiny pores in film 102 and reaches the underlying photoresist, where it plasticizes and eventually dissolves the photoresist, rupturing the overlying film 102 in the process. This causes both the photoresist and the film to be carried away by the stripping solution. However, in regions not undercoated by photoresist, the film remains intact. Thus the photoresist coating on the ball effectively acts as a "negative" that is "developed" by the photoresist stripping solution into a thin-film "positive": specifically, a photoresist aperture mask coating (as depicted in FIG. 10) yields a spherical lens having a thin-film aperture stop, and a photoresist aperture stop yields a spherical lens having a thin-film aperture mask.

Detailed Description Text (124):
The incident light that encounters a gyricon display need not be restricted to visible light. Given suitable materials for the gyricon balls, the incident "light" can be, for example, infrared light or ultraviolet light, and such light can be modulated by the gyricon.

CLAIMS:

9. The combination of claim 1 wherein the optically transmissive region of the particle comprises a spheroidal ball.